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ROYAL ASTRONOMICAL SOCIETY
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VOL. XIV OCTOBER, 1920 No. 8

MODERN THEORIES OF THE SPIRAL NEBULAE [1]

BY HEBER D. CURTIS

In one sense, that theory of the spiral nebulae to which many lines of recently obtained evidence are pointing, can not be said to be a modern theory. There are few modern concepts which have not been explicitly or implicitly put forward as hypotheses or suggestions long before they were actually substantiated by evidence.

The history of scientific discovery affords many instances where men with some strange gift of intuition have looked ahead from meagre data, and have glimpsed or guessed truths which have been fully verified only after the lapse of decades or centuries. Herschel was such a fortunate genius. From the proper motions of a very few stars he determined the direction of the sun's movement nearly as accurately, due to a very happy selection of stars for the purpose, as far more elaborate modern investigations. He noticed that the star clusters which appeared nebulous in texture in smaller telescopes and with lower powers, were resolved into stars with larger instruments and higher powers. From this he argued that all the nebulae could be resolved into stars by the application of sufficient magnifying power, and that the nebulae were, in effect, separate universes, a theory which had been earlier suggested on purely hypothetical or philosophical grounds, by

[1] Abstract of a lecture given on March 15, 1919, at a joint meeting of the Washington Academy of Sciences and the Philosophical Society of Washington. The lecture was illustrated with numerous lantern slides.

Wright, Lambert, and Kant. From their appearance in the telescope he, again with almost uncanny prescience, excepted a few as definitely gaseous and irresolvable.

This view held sway for many years; then came the results of spectroscopic analysis showing that many nebulae (those which we now classify as diffuse or planetary) are of gaseous constitution and cannot be resolved into stars. The spiral nebulae, although showing a different type of spectrum, were in most theories tacitly included with the known gaseous nebulae.

We have now, as far as the spiral nebulae are concerned, come back to the standpoint of Herschel's fortunate, though not fully warranted, deduction; and the theory to which much recent evidence is pointing is that these beautiful objects are separate galaxies, or "island universes", to employ the expressive and appropriate phase coined by Humboldt.

By means of direct observations on the nearer and brighter stars, and by the application of statistical methods to large groups of the fainter or more remote stars, the galaxy of stars which forms our own stellar universe is believed to comprise perhaps a billion suns. Our sun, a relatively inconspicuous unit, is situated near the centre of figure of this galaxy. This galaxy is not even approximately spherical in contour, but shaped like a lens or thin watch. The actual dimensions are highly uncertain; Newcomb's estimate that this galactic disk is about 3,000 light-years in thickness, and 30,000 light-years in diameter, is perhaps as reliable as any other.

Of the three classes of nebulae observed, two, the diffuse nebulosities and the planetary nebulae, are typically a galactic phenomenon as regards their apparent distribution in space, and are rarely found at any distance from the plane of our Milky Way. With the exception of certain diffuse nebulosities whose light is apparently a reflection phenomenon from bright stars involved within the nebulae, both these types are of gaseous constitution, showing a characteristic bright-line spectrum.

Differing radically from the galactic gaseous nebulae in form and distribution, we find a very large number of nebulae predominantly spiral in structure. The following salient points must be taken into account in any adequate theory of the spiral nebulae.

1. In apparent size the spirals range from minute flecks, just distinguishable on the photographic plate, to enormous spirals like *Messier* 33 and the Great Nebula in Andromeda, the latter of which covers an area four times greater than that subtended by the full moon.

2. Prior to the application of photographic methods, fewer than ten thousand nebulae of all classes had been observed visually. One of the first results deduced by Director Keeler from the programme of nebular photography which he inaugurated with the Crossley Reflector at Lick Observatory, was the fact that great numbers of small spirals are within reach of modern powerful reflecting telescopes. He estimated their total number as 120,000 early in the course of this programme, and before plates of many regions were available. I have recently made a count of the small nebulae on all available regions taken at the Lick Observatory during the past twenty years[1] and from these counts estimate that there are at least 700,000 spiral nebulae accessible with large reflectors.

3. The most anomalous and inexplicable feature of the spiral nebulae is found in their peculiar distribution. They show an apparent abhorrence for our galaxy of stars, being found in greatest numbers around the poles of our galaxy. In my counts I found an approximate density of distribution as follows:

Galactic Latitude $+45°$ to $+90°$	34 per square degree.
Galactic Latitude $-45°$ to $-90°$	28 per square degree.
Galactic Latitude $+30°$ to $+45°$ and $-30°$ to $-45°$	24 per square degree.
Galactic Latitude $-30°$ to $+30°$	7 per square degree.

No spiral has as yet been found actually within the structuer of the Milky Way. We have doubled and trebled our exposures in regions near the galactic plane in the hope of finding fainter spirals in such areas, but thus far without results. The outstanding feature of the space distribution of the spirals is, then, that they are found in greatest profusion where the stars are fewest, and do not occur where the stars are most numerous. This distribution may be illustrated graphically as follows:

[1] Curtis, H. D. *On the number of spiral nebulae*, Proc. Amer. Phil. Soc. 57: 513. 1918.

THE FACTOR OF SPACE DISTRIBUTION

400,000±Spiral Nebulae

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Our own stellar universe
is shaped like a thin lens, and is perhaps
3,000 by 30,000 light-years in extent. In this
space occur nearly all the stars, nearly all the new stars, nearly
all the variable stars, most of the diffuse and
planetary nebulae, etc., but *no spiral*
nebulae.

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300,000±Spiral Nebulae.

4. The spectrum of the spirals is practically the same as that given by a star cluster, showing a continuous spectrum broken by absorption lines. A few spirals show bright-line spectra in addition.

5. The space-velocities of the various classes of celestial objects are summarized in the following short table:

THE FACTOR OF SPACE-VELOCITY

1. *The Diffuse Nebulae.*
   Velocities low.
2. *The Stars.*
   Velocities vary with spectral type.

Class B Stars: average speeds 8 miles per second.
Class A Stars: average speeds 14 miles per second.
Class F Stars: average speeds 18 miles per second.
Class G Stars: average speeds 19 miles per second.
Class K Stars: average speeds 21 miles per second.
Class M Stars: average speeds 21 miles per second.

3. *The Star Clusters.*
   Velocities perhaps 150 miles per second.
4. *The Planetary Nebulae.*
   Average speeds 48 miles per second.
5. *The Spiral Nebulae.*
   Average speeds 480 miles per second.

The peculiar variation of the space-velocity of the stars with spectral type may ultimately prove to be a function of relative mass. The radial velocities of but few spirals have been determined to date; future work may change the value given, but it seems certain that it will remain very high.

It will be seen at once that, with regard to this important criterion of space-velocity, the spiral nebulae are very distinctly in a class apart. It seems impossible to place them at any point in a coherent scheme of stellar evolution. We can not bridge the gap involved in postulating bodies of such enormous space velocities either as a point of stellar origin, or as a final evolution product.

On the older theory that the spirals are a part of our own galaxy, it is impossible to harmonize certain features of the data thus far presented. If this theory is true, their grouping near the galactic poles, inasmuch as all evidence points to a flattened or disk form for our galaxy, would indicate that they are relatively close to us. In that event, we should inevitably have detected in this class of objects proper motions of the same order of magnitude as those found for the stars at corresponding distances. Such proper motions are the more to be expected in view of the fact that the average space velocity of the spirals is about thirty times that of the stars. I have repeated all the earlier plates of the Keeler nebular programme, and was able to find no certain evidence of either translation or rotation in these objects in an average time interval of thirteen years.[1] Their form, and the evidence of the spectroscope, indicate, however, that they are in rotation. Knowing that their space-velocities are high, the failure to detect any certain evidence of cross motion is an indication that these objects must be very remote.

Even if the spiral is not a stage in stellar evolution, but a class

[1] Curtis, H. D. *The proper motion of the nebulae.* Publ. Astron. Soc. Pacific 27: 214. 1915.

apart, is it still possible to assume that they are, notwithstanding, an integral part of our own stellar universe, sporadic manifestations of an unknown line of evolutionary development, driven off in some mysterious manner from the regions of greatest star density?

A relationship between two classes of objects may be one of avoidance just as logically as one of contiguity. It has been argued that the absolute avoidance which the spirals manifest for the galaxy of the stars shows incontrovertibly that they must, by reason of this very relationship of avoidance, be an integral feature of our galaxy. This argument has proved irresistible to many, among others to so keen a thinker as Herbert Spencer, who wrote:

"In that zone of celestial space where stars are excessively abundant nebulae are rare; while in the two opposite celestial spaces that are furthest removed from this zone nebulae are abundant. . . . Can this be mere coincidence? When to the fact that the general mass of the nebulae are antithetical in position to the general mass of the stars, we add the fact that local regions of nebulae are regions where stars are scarce . . . does not the proof of a physical connection become overwhelming?"

It must be admitted that a distribution, which has placed three-quarters of a million objects around the poles of our galaxy, would be against all probability for a class of objects which would be expected to be arranged at random, unless it can be shown that this peculiar grouping is only apparent, and due to some phenomenon in our own galaxy. This point will be reverted to later.

It has been shown that the factors of space-velocity and space-distribution separate the spirals very clearly from the stars of our galaxy; from these facts alone, and from the evidence of the spectroscope, the island universe theory is given a certain measure of credibility.

Another line of evidence has been developed within the past two years, which adds further support to the island-universe theory of the spiral nebulae.

New Stars

Within historical times some twenty-seven new stars have suddenly flashed out in the heavens. Some have been of interest only to the astronomer; others, like that of last June, have rivalled *Sirius* in brilliancy. All have shown the same general history, suddenly increasing in light ten thousand-fold or more, and then gradually, but still relatively rapidly, sinking into obscurity again. They are a very interesting class, nor has astronomy as yet been able to give any universally accepted explanation of these anomalous objects. Two of these novae had appeared in spiral nebulae, but this fact had not been weighed at its true value. Within the past two years over a dozen novae have been found in spiral nebulae, all of them very faint, ranging from about the fourteenth to the nineteenth magnitudes at maximum. Their life history, so far as we can tell from such faint objects, appears to be identical with that of the brighter novae. Now the brighter novae of the past, that is, those which have not appeared in spirals, have almost invariably been a galactic phenomenon, located in or close to our Milky Way, and they have very evidently been a part of our own stellar system. The cogency of the argument will, I think, be apparent to all, although the strong analogy is by no means a rigid proof. If twenty-seven novae have appeared in our own galaxy within the past three hundred years, and if about half that number are found within a few years in spiral nebulae far removed from the galactic plane, the presumption that these spirals are themselves galaxies composed of hundreds of millions of stars is a very probable one.

If, moreover, we make the reasonable assumption that the new stars in the spirals and the new stars in our own galaxy average about the same in size, and absolute brightness, we can form a very good estimate of the probable distance of the spiral nebulae, regarded as island universes. Our galactic novae have averaged about the fifth magnitude. The new stars which have appeared in the spiral nebulae have averaged about the fifteenth magnitude, but it would appear probable that we must inevitably miss the fainter novae in such distant galaxies, and it is perhaps reasonable to assume that the average magnitude of the novae in spirals may

be about the eighteenth, or thirteen magnitudes fainter than those in our own galaxy. They would thus be about 160,000 times fainter than our galactic novae, and on the assumption that both types of novae average the same in mass, absolute luminosity, etc., the novae in spirals should be four hundred times further away. We do not know the average distance of the new stars which have appeared in our own galaxy, but 10,000 light years is perhaps a reasonable estimate. This would indicate a distance of the order of 4,000,000 light-years for the spiral nebulae.[1] This is an enormous distance, but, if these objects are galaxies like our own stellar system, such a distance accords well with their apparent dimensions. Our own galaxy, at a distance of 10,000,000 light years, would be about 10 minutes of arc in diameter, or the size of the larger spiral nebulae.

On such a theory, a spiral structure for our own galaxy would be probable. Its proportions accord well with the degree of flattening observed in the majority of the spirals. We have very little actual evidence as to a spiral structure for our galaxy; the position of our sun relatively close to the centre of figure of the galaxy, and our ignorance of the distances of the remoter stars, renders such evidence very difficult to obtain. A careful study of the configurations and star densities in the Milky Way has led Professor Easton, of Amsterdam, to postulate a spiral structure for our galaxy.

Disrtibution of Spirals

There is still left one outstanding and unexplained problem in the island universe theory or any other theory of the spiral nebulae. Neither theory, as outlined, offers any satisfactory explanation of the remarkable distribution of the spirals. On the older theory, if a feature of our galaxy, what has driven them out to the points most remote from the regions of greatest star density? If, on the other hand, the spirals are island universes, it is against all probability that our own universe should have chanced to be situated about half way between two great groups

[1] Recent parallaxes of 4 novae indicate smaller distance for galactic novae, so that the Andromeda nebula is probably 500,000 to 1,000,000 l.y. distant.

of island universes, and that not a single object of the class happens to be located in the plane of our Milky Way.

There is one very common characteristic of the spirals which may be tentatively advanced as an explanation of the peculiar grouping of the spirals.

A very considerable proportion of the spirals show indubitable evidence of occulting matter, lying in the plane of the greatest extension of the spiral, generally outside the whorls, but occasionally between the whorls as well. This outer ring of occulting matter is most easily seen when the spiral is so oriented in space as to turn its edge toward us. But the phenomenon is also seen in spirals whose planes make a small, but appreciable angle with our line of sight, manifesting itself in such appearances as "lanes" more prominent on one side of the major axis of the elongated elliptical projection, in a greater brightness of the nebular matter on one side of this major axis, in a fan-shaped nuclear portion, or in various combinations of these effects. The phenomenon is a very common one. Illustrations of seventy-eight spirals showing evidences of occulting matter in their peripheral equatorial regions, with a more detailed discussion of the forms observed, are now being published.[1] and additional examples of the phenomenon are constantly being found.

While we have as yet no definite proof of the existence of such a ring of occulting matter lying in our galactic plane and outside of the great mass of the stars of our galaxy, there is a great deal of evidence for such occulting matter in smaller areas in our galaxy. Many such dark areas are observed around certain of the diffuse nebulosities, or seen in projection on the background furnished by such nebulosities or the denser portions of the Milky Way; these appearances seem to be actual "dark nebulae".[2] The curious "rifts" in the Milky Way may well be ascribed, at least in part, to such occulting matter.

[1] Curtis, H. D. *A study of Occulting effects in the spiral nebulae.* Lick. Observ. Publ. Vol. XIII, Part II.

[2] BARNARD, E. E. *On the dark markings of the sky,* with a catalogue of 182 such objects. Astrophys. Journ. 49: 1. 1919; Curtis, H. D. *Dark nebulae.* Publ. Astron. Soc. Pacific 30: 65. 1918.

Though we thereby run the risk of arguing in a circle, the fact that no spirals can be detected in our galactic plane, a natural result of such a ring of occulting matter, would in itself appear to lend some probability to the hypothesis. The peculiar distribution of the spiral nebulae would then be explained as due, not to an actual asymmetrical and improbable distribution in space, but to a cause within our own galaxy, assumed to be a spiral with a peripheral ring of occulting matter similar to that observed in a large proportion of the spirals. The argument that the spirals must be an integral feature of our own galaxy, based on a relationship of avoidance, would then lose its force. The explanation appears to be a possibility, even a strong probability, on the island universe theory, and I know of no other explanation, on any theory, for the observed phenomenon of nebular distribution about our galactic poles.

SUMMARY

The Spiral Nebulae as Island Universes.

1. On this theory, it is unnecessary to attempt to co-ordinate the tremendous space-velocities of the spirals with the thirty-fold smaller values found for the stars. Very high velocities have been found for the Magellanic Clouds, which may possibly be very irregular spirals, relatively close to our galaxy.

2. There is some evidence for a spiral structure in our own galaxy.

3. The spectrum of the majority of the spirals is practically identical with that given by a star cluster; a spectrum of this general type is such as would be expected from a vast congeries of stars.

4. If the spirals are separate universes, similar to our galaxy in extent and in number of component stars, we should observe many new stars in the spirals, closely resembling in their life history the twenty-seven novae which have appeared in our own galaxy. Over a dozen such novae in spirals have been found, and it is probable that a systematic programme of repetition of nebular photographs will add greatly to this number. A comparison of

the average magnitudes of the novae in spirals with those of our own galaxy indicates a distance of the order of 10,000,000 light-years for the spirals. Our own galaxy at this distance would appear 10′ in diameter, the size of the larger spirals.

5. A considerable proportion of the spirals show a peripheral equatorial ring of occulting matter. So many instances of this have been found that it appears to be a general though not universal characteristic of the spirals; the existence of such an outer ring of occulting matter in our own galaxy, regarded as a spiral, would furnish an adequate explanation of the peculiar distribution of the spirals. There is considerable evidence of such occulting matter in our galaxy.

An English physicist has cleverly said that any really good theory brings with it more problems than it removes. It is thus with the island-universe theory. It is impossible to do more than to mention a few of these problems, with no attempt to divine those which may ultimately be presented to us.

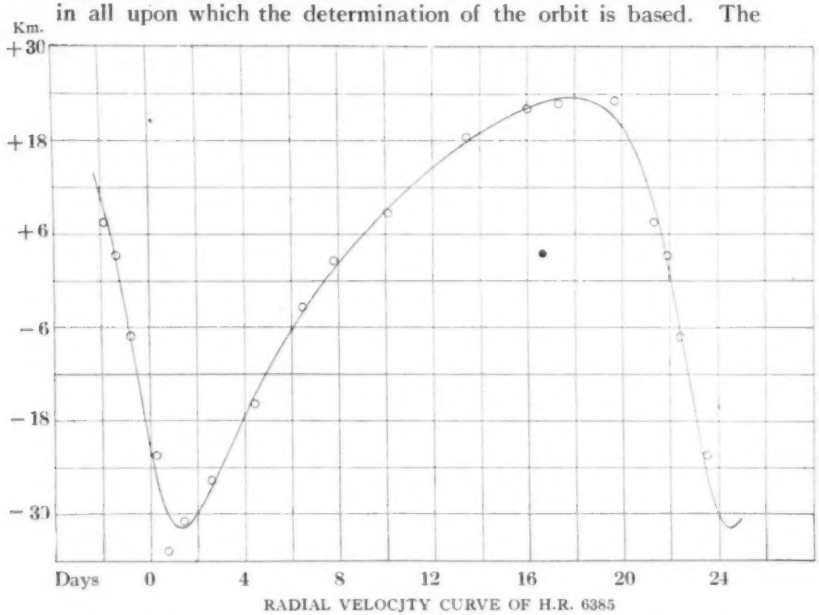
While the data are too meagre as yet, several attempts have been made to deduce the velocity of our own galaxy within the super-galaxy. It would not be surprising if the space-velocity of our galaxy, like those of the spirals of the Magellanic Clouds, should prove to be very great, hundreds of miles per second.

Further, what are the laws which govern the forms assumed, and under which these spiral whorls are shaped? Are they stable structures; are the component stars moving inward or outward? A beginning has been made by Jeans and other mathematicians on the dynamical problems involved in the structure of the spirals. The field for research is, like our subject matter, practically infinite.

THE ORBIT OF THE SPECTROSCOPIC BINARY H.R. 6385

By W. E. Harper

This star (1900 $\alpha = 17h\ 06.1m$, $\delta = +12°\ 35'$, visual magnitude 6.46, type A2) was found to be a spectroscopic binary from observations made here by Dr. R. K. Young in 1918 and 1919. Twenty-eight additional plates have been secured this season, making 32 in all upon which the determination of the orbit is based. The



RADIAL VELOCJTY CURVE OF H.R. 6385

data concerning these plates are given in the table of observations following, the successive columns being self-explanatory. For the first plate the mean of measures by Young and the writer is used. The residuals O−C are scaled from the final curve and should be accurate to 0.1 or 0.2 km at most. The period obtained from connecting up the observations over the 3 years was 23.245 days and

it was felt unnecessary to include this element in the least-squares solution. The phases, then, are reckoned from the date of periastron finally adopted, using this value of the period.

OBSERVATIONS OF H.R. 6385

Plate Number	Date	Julian Date	Phase	Velocity	Lines	Residual O-C
263	1918 June 28	2,421,773.821	16.78	+25.6	16	+2.6
1955	1919 May 4	2,083.922	1.45	−32.0	11	+0.4
2276	July 6	146.765	17.80	+20.5	12	−2.9
2860	Aug. 29	200.661	1.93	−28.5	10	+1.3
3866	1920 Mar. 2	386.037	1.38	−29.9	9	+1.8
4013	April 5	420.937	13.03	+21.8	11	+4.9
4031	" 7	422.957	15.05	+17.2	16	−3.4
4052	" 9	424.917	17.01	+23.2	15	−0.1
4080	" 12	427.917	20.01	+25.2	10	+5.4
4096	" 14	429.004	21.10	+ 9.7	5	−2.4
4141	" 23	438.923	7.77	+ 2.8	15	+1.3
4165	" 25	440.946	9.80	+ 8.5	12	+0.3
4189	" 30	445.927	14.78	+16.9	13	−3.4
4209	May 2	447.929	16.78	+26.0	14	+0.3
4220	" 3	448.926	17.78	+24.0	12	+0.6
4247	" 5	450.930	19.78	+21.7	16	+1.2
4315	" 19	464.835	10.44	+ 8.9	14	−1.3
4332	" 21	466.862	12.47	+16.4	13	+0.7
4345	" 24	469.851	15.46	+19.4	14	−1.9
4357	" 30	475.806	21.41	+ 6.8	14	−1.8
4369	" 31	476.807	22.41	− 5.6	20	+1.3
4370	" 31	476.830	22.44	− 9.2	16	−2.2
4385	June 1	477.897	0.26	−22.5	15	+3.1
4444	" 20	496.810	19.17	+23.3	9	+1.1
4462	" 25	501.819	0.93	−34.8	17	−3.7
4477	" 27	503.794	2.91	−24.0	17	+0.3
4482	" 28	504.815	3.93	−19.8	17	−2.4
4500	" 29	505.800	4.92	−12.2	16	−0.5
4509	" 30	506.770	5.88	− 4.8	16	+2.0
4525	July 1	507.809	6.92	−2.2	22	−0.2
4533	" 2	508.721	7.84	+ 2.3	16	+0.8
4633	1920 July 16	2,422,522.729	21.84	+ 3.2	11	+0.4

The maximum of the curve is smooth and rounded and more observations than were really necessary there were secured before the true form of the curve was recognized. The observations were, however, grouped into 15 normal places, preliminary elements obtained in the usual graphical way, and a least-squares solution effected giving the following results.

FINAL ELEMENTS

P = 23.245 days
e = .427 ± .014
ω = 129°.85 ± 2.46
γ = +3.51 km. ± 0.30 km.
K = 27.67 km. ± 0.45 km.
T = J. D. 2,421,780.290 ± 0.116 days
$a \sin i$ = 7,997,400 km.
$\frac{m^3_1 \sin^3 i}{(m+m_1)^2} = 0.038 \odot$

The solution improved the agreement considerably, the sum of the squares of the residuals for the normal places being reduced from 128.7 to 76.7. One solution was found to be sufficient. The probable error of a plate as determined from the last two columns of the table of observations is ±1.50 km. per sec. and is satisfactory for this type of spectrum measured on the micrometer engine.

DOMINION ASTROPHYSICAL OBSERVATORY,
VICTORIA, B.C.
July 22nd, 1920.

MAGNETIC RESULTS, 1919

C. A. FRENCH

As in the preceding season the field work of the Dominion Observatory for 1919 was confined to stations previously occupied for the purpose of securing secular variation data. In all, sixty-four stations were occupied, though they represent only fifty-five district localities. Three of the stations were approximately re-locations of Carnegie Institution stations, which were in the vicinity of Dominion Observatory stations, and six represent new stations, selected on account of the probable unsuitability of the old sites for future observations. In addition spring and fall observations were taken at Ottawa, as well as a series of standardizing comparisons at the Agincourt Magnetic Observatory in the spring and fall. With the exception of one station, Sudbury, Ont., all the field work was confined to Western Canada, or to the area lying between longitude 97°.2 and 130°.4 W. and between latitude 49°.0 and 54°.8 N.

The instruments used throughout the season were the same as were used during 1918, namely, half-seconds chronometer, Bond No. 511; and the combined magnetometer *and* dip circle C.I.W. No. 20.

The results of the standardizing comparisons made between magnetometer C.I.W. No. 20 and the various standards at Agincourt are given in Table A.

TABLE A—I.M.S.—NO. 20

Date	Declination	Hor. Int.	Dip with needle No. 1	No. 2	No. 5	No. 6
1919						
April	−0.8	−0.00041*H*				
October	−0.4	−0.00075*H*	−1.5	−1.6	+0.8	+2.2
Mean	−0.6	−0.00058*H*	−1.5	−1.6	+0.8	+2.2

The results of the observations taken at the stations occupied during 1919, and the average annual change deduced from these observations are summarized in Table B. The majority of the observations used to determine the secular change were obtained

by the Dominion Observatory, a few by the Carnegie Institution and one station, Swift Current, was occupied by the Meteorological Service of Canada.

A negative or minus sign under "Dec" indicates that easterly declination, which is designated by plus, is decreasing; while westerly declination, designated by the minus sign, is increasing.

DOMINION OBSERVATORY,
OTTAWA,
June 26th, 1920.

[*Table on next two pages.*]

TABLE B

Station	Lat.	Long.	Date	Declination Value	Declination Daily Range	Dip.	Hor. Int.	Total Int.	Average Annual Change Mean Date	Dec.	Dip.	Hor. Int.
	° ′	° ′		West ° ′	′	° ′	c.g.s.	c.g.s.		′	′	γ
Ottawa	45 23.6	75 43.0	Apr. 23 May 7									
Sudbury	46 30.9	81 01.5	Nov. 7-13	13 38.6	08.3	75 40.8	.14864	.60093	1916.1	−3.7	+0.1	−29
			May 13-14	7 56.4	15.5	76 31.3	.14346	.61550	1916.4	−2.2	+0.2	−22
Winnipeg	49 51.9	97 10.0	" 26-27	East 13 23.5	17.5	78 08.7	.12896	.62774	1916.0	−3.7	−0.4	−13
Oak Point	50 30.3	98 02.6	" 28-29	12 58.2	17.2	78 21.2	.12645	.62638	1918.0	−3.0	−1.1	−11
Gypsumville A.	51 46.5	98 36.5	" 31 June 2	12 30.7	26.6	78 46.0	.12248	.62873	1918.0	−3.7	−1.1	−04
Gypsumville B.	51 46.5	98 36.5	" 31	12 28.7	19.9	78 46.3	.12240	.62860				
Riverton	51 00.1	97 00.4	Jun. 4	11 42.2	20.0	78 58.0	.11963	.62509	1918.0	−2.6	−1.1	−11
Gladstone	50 13.3	98 57.0	" 6	13.45.6	——	77 58.2	.13002	.62382	1915.6	−3.6	−0.5	−13
Dauphin	51 09.0	100 03.9	" 7-9	14 52.0	26.5	78 20.1	.12746	.63040	1915.6	−4.3	−0.5	−10
[1]Swan River D.O.	52 06.8	101 16.1	" 11	18 14.2	19.9	79 00.5	.11980	.62832	1915.2	−3.6	−0.6	−08
Swan River C.I.	52 06.8	101 16.1	" 13	18 08.1	23.5	79 02.0	.11977	.62958	1914.1	−3.0	−0.2	−11
Hudson Bay Jct.	52 51.9	102 23.7	" 14-16	18 26.8	23.7	79 17.3	.11587	.62340	1915.6	−4.1	−0.6	−09
The Pas	53 50.0	101 13.8	" 17-18	18 22.7	18.0	80 03.1	.10824	.62653	1914.1	−3.4	−0.3	−08
Melford	52 51.5	104 37.4	" 19-20	20 34.0	17.0	78 56.0	.11980	.62412	1915.6	−3.7	−0.6	−05
Prince Albert	53 11.7	105 46.6	" 21-23	22 55.7	28.2	79 10.3	.11759	.62592	1915.6	−3.5	−0.4	−09
Warman	52 19.2	106 33.7	" 24-25	23 52.0	20.3	77 48.0	.13103	.62004	1915.6	−2.9	−0.6	−11
Battleford	52 43.6	108 17.9	" 26-27	22 52.9	17.8	77 37.4	.13252	.61827	1915.6	−2.4	−0.5	−11
[2]Lloydminister D.O.	53 17.4	110 00.4	" 28-29	25 10.3	23.4	77 59.0	.12856	.61750	1915.6	−2.5	−0.6	−08
Lloydminister C.I.	53 17.6	110 00.0	" 30	25 09.0	18.7	77 58.1	.12856	.61674	1914.2	−1.3	−0.8	−04
Vegreville	53 29.9	112 01.9	July 1-2	26 57.1	20.8	77 34.5	.13260	.61628	1915.6	−2.5	−0.8	−08
Bruderheim	53 48.6	112 55.3	" 3	26 43.0	16.8	77 32.8	.13264	.61508	1915.5	−1.8	−0.5	−09
[3]Lacombe D.O.	52 27.6	113 45.2	" 4	25 51.5	17.3	76 22.9	.14397	.61146	1915.5	−1.6	−0.5	−09
Lacombe C.I.	52 28.5	113 43.0	" 5	25 53.6	14.5	76 22.6	.14391	.61098				
Wabamun	53 33.7	114 28.5	" 7-8	26 50.3	17.8	77 12.5	.13592	.61389	1916.6	−2.2	−0.7	−12
Edson	53 35.5	116 26.5	" 9-10	28 36.8	16.4	76 34.1	.14217	.61205	1916.6	−1.2	−0.5	−07
Jasper	52 53.3	118 04.7	" 12-13	27 15.9	19.0	75 26.7	.15178	.60395	1916.6	−1.2	−0.2	−14
McBride	53 18.1	120 10.4	" 14-15	28 19.8	15.8	75 13.3	.15358	.60208	1916.6	−0.3	−0.3	−12
South Fort George	53 54.6	122 44.8	" 17-19	28 42.0	18.3	75 08.7	.15278	.59593	1917.6	−1.1	−0.3	−08
Endako	54 04.9	125 02.2	" 20-21	29 07.3	16.2	74 55.0	.15422	.59264	1917.6	+0.8	−0.3	−10
Smithers	54 47.4	127 11.8	" 22-23	29 35.3	20.5	74 58.8	.15361	.59273	1917.6	0.0	0.0	−03
Pacific	54 45.8	128 15.9	" 25-26	29 18.8	15.8	74 24.0	.15834	.58880	1917.6	0.8	−0.5	−10
Prince Rupert	54 18.2	130 20.1	" 28-29	29 00.9	16.2	73 34.4	.16424	.58079	1917.6	0.0	−1.0	−08

TABLE B—*Continued*

Station	Lat.	Long.	Date	Declination		Dip	Hor. Int.	Total Int.	Average Annual Change			
				Value	Daily Range				Mean Date	Dec.	Dip	Hor. Int.
	° ′	° ′		East ° ′	′	° ′	c.g.s.	c.g.s.		′	′	γ
Ocean Falls	52 21.3	127 40.8	July 31	27 12.2	14.8	73 01.0	.16984	.58146				
Victoria	48 25.0	123 22.8	Aug. 4-5	24 43.6	6.0	71 11.3	.18666	.57887	1914.2	+1.0	−0.7	−06
Nanaimo	49 12.8	123 56.1	" 7	25 26.6	——	71 13.0	.18688	.58039	1914.2	+1.2	−0.7	−08
*a*Vancouver	49 17.8	123 07.0	" 9-10	25 18.4	13.4	71 17.9	.18853	.58798	1917.6	−4.8	−4.0	28
[4] North Bend A	49 52.7	121 27.3	" 12 13	25 58.0	7.6	72 24.6	.17815	.58950				
North Bend B	49 52.7	121 27.1	" 13-14	25 47.4	15.0	72 29.0	.17766	.59027	1914.2	+1.0	−0.6	−10
Ashcroft	50 43.6	121 16.9	" 15	27 50.1	19.5	73 19.5	.17138	.59726	1914.2	+0.4	−0.7	−05
Kamloops	50 40.8	120 20.7	" 16-18	25 52.2	15.2	73 12.9	.17064	.59090	1917.6	0.0	−0.2	−20
Sicamous	50 50.3	119 01.2	" 19	25 49.9	15.4	73 49.1	.16648	.59738	1917.6	−0.8	−0.5	−10
Okanagon Landing	50 13.9	119 21.0	" 20-21	25 18.1	11.6	73 06.6	.17238	.59332	1917.6	−0.5	0.0	−22
Penticton	49 29.3	119 25.9	" 22	25 30.9	13.4	72 37.6	.17785	.59562	1917.6	0.0	−0.2	−22
Midway	49 00.0	118 47.0	" 23-25	24 24.2	15.5	72 17.4	.18008	.59198	1917.6	0.0	−0.5	−15
Nelson	49 29.7	117 16.7	" 26-27	24 29.7	17.1	72 53.6	.17579	.59762	1917.6	−0.2	−0.2	−17
Proctor	49 37.0	116 57.0	" 28	24 27.0	21.4	73 22.1	.17156	.59940	1917.6	−1.0	0.0	−12
[5] Cranbrook A	49 31.0	115 47.2	" 30-31	24 26.7	14.7	73 29.4	.17065	.60050	1917.6	−0.7	−0.5	−17
Cranbrook B	49 31.0	115 47.2	Sept. 1	24 25.9	17.9	73 30.0	.17081	.60141				
Frank	49 36.4	114 23.2	" 2-3	24 06.4	21.8	74 02.6	.16560	.60238	1917.6	−1.6	0.0	−26
MacLeod	49 43.1	113 24.9	" 4	23 35.[illegible]	9.6	74 32.7	.16234	.60920	1917.6	−0.9	+0.4	−16
Banff	51 10.7	115 35.5	" 7-8	26 04.5	15.4	74 54.9	.15804	.60727	1915.6	−1.0	−0.1	−15
Morley	51 09.3	114 51.1	" 9	24 40.0	——	75 08.2	.15651	.61014	1915.6	−0.6	+0.2	−20
Gleichen	50 52.2	113 03.3	" 10-12	24 16.8	17.2	75 28.2	.15370	.61262	1915.6	−1.1	0.0	−18
Tilley	50 27.2	111 38.8	" 13-14	22 57.3	15.6	75 26.2	.15324	.60942	1915.6	−1.3	−0.1	−17
Dunmore	49 58.5	110 35.6	" 15	21 48.5	9.4	75 23.4	.15449	.61248	1917.6	−1.6	−0.2	−19
Maple Creek	49 54.6	109 30.0	" 16	22 13.3	14.6	75 26.4	.15409	.61294	1915.6	−1.2	−0.1	−18
Swift Current	50 16.3	107 48.4	" 17-18	20 58.2	7.1	76 15.2	.14670	.61735	1915.6	−1.9	−0.1	−14
[6] Chaplin A	50 28.0	106 39.5	" 21-22	20 47.6	11.8	76 39.6	.14304	.61995	1915.6	−2.4	−0.1	−19
Chaplin B	50 28.0	106 39.5	" 22-23	20 47.1	18.2	76 39.2	.14296	.61930				
Pense	50 24.7	104 59.1	" 24-25	19 21.3	18.0	76 52.5	.14050	.61874	1915.2	−2.7	−0.2	−17
Wolseley A	50 26.3	103 15.5	" 27-28	17 51.3	13.4	77 20.7	.13687	.62475	1915.2	−2.9	0.0	−17
Wolseley B	50 25.5	103 15.0	" 26-27	17 48.5	14.2	77 19.8	.13710	.62507				
Kirkella	50 01.9	101 22.4	" 29-30	15 43.8	16.2	77 17.8	.13754	.62546	1915.2	−3.3	0.0	−18
[7] Brandon A	49 52.0	99 58.8	Oct. 2-3	14 27.8	——	77 35.8	.13464	.62684				
Brandon B	49 52.0	99 58.3	" 4	14 36.4	19.4	77 34.6	.13464	.62584				

[1] D.O. station is about 420 feet southeast of C.I. station.
[2] D.O. station is about one-half mile northeast C.I. station.
[3] D.O. station is about one mile southeast of C.I. station.
[4] Station B is about one-third of a mile east of station A.
[5] Station B is 388 feet northwesterly from station A.
[6] Station B is 235 feet southwesterly from staion A.
[7] Station B is about one-half mile east of staion A.
a These values appear doubtful when compared with results at adjacent stations.

THE FESTIVAL OF THE DEAD

By R. G. Haliburton

(*Continued from page 259*)

not numbered with the months, nor included in the days of the year.

As these *dies nefasti* fell, in the Egyptian calendar, about the end of August, when the Egyptian year began, when the Romans believed the world of Spirits to be opened, and illuminated the city with bonfires, and at the very same time that the Japanese now hold their lanthorn festival, we can scarcely arrive at any other conclusion than that these festivals, at the end of August, are memorials of a common primitive calendar, based on some simple natural law, that caused and preserved this striking uniformity, in countries so widely separated, and through a lapse of so many centuries.

These various identities in the festivals of nations have never been the subject of regular investigation; and nothing yet laid down by astronomers, respecting any ancient calendar, can in any way account for the existence of such remarkable coincidences, traceable in all ages and to all portions of the globe, among the Egyptians, the most learned of ancients nations, and among the Australians, the most degraded of savages.

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days of the year; let them not come into the number of the months." That offerings to the dead were made in those days is proved by Egyptian monuments. See Bunsen's Egypt's Place in Universal History, iii. 63, 70, where reference is made to the researches of Leipsius on this point—Leipsius Ein. 91, 92. The same fable as to the gods playing at dice is connected with the month of Cartica by the Hindoos.—See Sir Wm. Jones' Works, iv. 113.

Proofs from Astronomy and Chronology, that in Relation to the Pleiades Our Calendar Now Exactly Corresponds With the Primitive Year.

Πληιαδων φαινουσαν Αθυρ τεκμαιρεται ωρην.[1]

Assuming all these inferences to be correct, a difficulty will suggest itself to the reader, which may naturally seem fatal to the conclusions at which I have arrived. It may be said, "It is true that these festivals falling among so many races at the present day, as well as among so many ancient nations, on the 17th November, in the middle of February, or at the end of August, appear to have been regulated by the culmination of the Pleiades at midnight, sunset, or sunrise, yet it is only a singular coincidence, that is, the result of accident. If those festivals now agree with the culminations of the Pleiades at the times named, yet they did not do so two thousand years ago. The Pleiades gain twenty-eight days on the tropical year in every two thousand years; hence the Pleiades that now culminate at midnight on the 17th November, did so in October two thousand years ago. Hence you must prove that the months have moved onward with the Pleiades, or all your assumptions fall to the ground." This difficulty, however, when inquired into, not only strengthens my conclusions, but also opens up a new question regarding calendars and chronology, that is in itself most important, as well as most interesting. It is evident that if the primitive year was regulated by the Pleiades, the months must have been gradually affected by the beginning of the year commencing one day later in every seventy-one years, and hence the first month, whether November, February, or August, if connected with a sidereal or astral year, must have moved onward in an equal ratio with the movements of these stars, and of course all the other months in the calendar must have shared equally in this progressive tendency.

No one hitherto has suspected that the primitive calendars of ancient nations were based on a sidereal year. Let us, however, see whether astronomers have not supplied us with facts that necessarily lead to this conclusion.

I may assume that if a sidereal year was the primitive basis of all calendars, astronomers must have been surprised to find *simultaneous and progressive changes* in calendars, which must have appeared to have been the result of *artificial "corrections."* If the primitive year was regulated by the culmination of the Pleiades at midnight, all derivative calendars would be found gradually to change, and yet to preserve a relation towards each other, and this connection would be traceable to the *point d'appui*

[1] Greek Anthologia, iii. 211. See also Fasti Catholici, iv. 192.

of these calendars, the day when the Pleiades culminate at midnight, sunset, or sunrise, by whichever the year was regulated. Let us see, then, what Greswell says on this point:—

"The *natural* measures of time have had only one *primum mobile,* one point of departure or epoch; which never has been, nor could be, nor is even at present, anything different from what it was at first. The civil calendar also might have had only one epoch and point of departure at first, though that is a matter of fact which we would not be justified in assuming without sufficient proof of its truth; but whatsoever it might have been at first, it would still be notorious and incontrovertible that, since the beginning of human society, it has had an almost infinite number of epochs, and points of departure; *a different one almost in every age, and in every country, and among every nation on the face of the earth.*"[2]

To analyse, compare, and to trace back to a primitive basis, calendars of apparently so variable a nature, at first may appear a task too difficult to be surmounted. This arises "from not merely the possibility, but the fact of the substitution of new types of the standard of nature, instead of the first and original one; from the various relations of these new ones compared with those of the old; and from the necessity of finding out and fixing the historical epoch of the substitution in each of these instances, and of tracing and following the subsequent history of such variations; of investigating in short, and ascertaining the whole cycle of the changes, transitions, and modifications in passing from one state to another successively, through which the original type of nature itself may have had to run."

"It follows that, when bringing down the primitive and universal type of the reckoning of annual civil time according to its natural law; we are bringing down at the same time in their elementary and primordial state, in their seminal principles, in their archetypal form, if not in their actual conditions and constitutions from the first, the civil calendars of all ages, and all countries, and all nations. Nor is it more unquestionable, in point of fact, that all existing distinctions of men (even those which are most widely discriminated in other respects) were originally summed up and comprehended in the loins of one man, and afterwards of three men, than that *the civil calendars of all such national divisions of mankind have been comprehended and embodied in this one type of all,* the civil calendar first of Adam, and next of three sons of Noah; and through them the common birthright and common inheritance of their posterity everywhere."[3]

[2] Fasti Cath., i. 40.
[3] Ib., 119.

I have already shown that the system of counting the day from sunset, which Greswell says is so universal as to prove the unity of origin of our race, and which he believes to have belonged to the primitive calendar, is still in existence in the southern hemisphere, and connected with the Halloween of the year of the Pleiades.[4] Let us see whether there are not some other land-marks of the primitive calendar that are relics of this system of regulating the year of the Pleiades. As the Egyptian and Hindoo calendars are the most important, let us see how far they exhibit traces of the progressive year of the Pleiades.

I have shown that the *Isia* were originally the new year's festival of the dead, and were connected always with the 17th of Athyr, and with the midnight culmination of the Pleiades. We find that the Egyptians had several modes of reckoning the year; two of them were perhaps in reality the same. The year commencing at the end of August was probably precisely the same as the primitive year commencing on the 17th day of Athyr or November. They would be both sidereal and subject to the same changes; but in the former the 17th day of Athyr (or November) is the 17th day of the third month. This therefore must be borne in mind, in reading the following remarks of Greswell respecting that day, which at least will prove that it was the *point d'appui* of all calendars, though the reason for this has, if I am correct, escaped the observation of Greswell, Bunsen, and other writers who refer to this subject:—

"It has been already seen that the Isia, among the Egyptians, were attached from the first to one particular month of their calendar, and to one particular day of that month; and that this particular month was the third, and this particular day was the 17th of the third month. And the calendar of the Egyptians, both at this time and long after it, being altogether the same with the primitive, the 17th of the third month in the civil calendar of the Egyptians, and the 17th of the third in the civil calendar common to all mankind, both at this time and long after it, were absolutely one and the same. It follows that the stated date of the Egyptian Isia, once fixed to the 17th of the third month in their proper calendar, was thereby fixed to the 17th of the third month too in the common calendar of all mankind; and as long as the proper Egyptian calendar and this common primitive calendar continued to be the same, and to preserve the same relation to each other, the 17th of the third month in either was the 17th of the third month in the other; and *vice versa*."

"This being the case, nothing being supposed to be known as yet respecting the Isia of the Egyptians, except these two facts,

[4] See ante, p. 18, 40, 74; note also p. 76. Fasti Cath., ii. 113.

that they were fixed to one month, the third in their proper calendar, and to one day, the 17th of that month; the attention of the reader is next to be directed to a very remarkable phenomenon, which the history of the primitive calendar, after a certain time, but not before, brings to light; viz., a succession of modifications, corrections, and changes of the primitive calendar itself on the cyclico-Julian principle, which we are able to trace in the retrograde order (that is, in the order of the recession of the equable in the Julian or natural year), all round the Julian or natural year, from the point at which it began, almost to the same point again: corrections or modifications of the primitive calendar, on this common principle, agreeing with each other not only in that respect, but in a still more remarkable and characteristic circumstance, that of being all attached to the same month of the primitive calendar, the third, and to the same day of this month, the 17th.

"The fact, which we have just pointed out, in the majority of these instances (and even in all, as we ourselves have seen reason to conclude) is confirmed by proofs that place it out of question; and the fact being admitted, it must be allowed to be something curious and remarkable in the highest degree; something which could not be resolved into an accidental occurrence of circumstances, in so many instances, in such different quarters of the world, and at such great distances of time asunder; and if it could not be explained on that principle, something which must have been the effect of design. Nothing but design, or reasons of a common kind, motives and causes which must have everywhere alike influenced such corrections, and alike determined the process of such corrections, could account for a coincidence like this, extending over a period of 1136 years, exemplified in fifteen different cases of the kind at least, yet all in the same way, and substantially to the same effect; beginning in India, the most remote quarter of the world of which anything was known to the ancients, and ending in Sweden or Norway, of which, until a very late point of time, they knew absolutely nothing.

"What, we may ask, must have been thought of this fact, had nothing been known concerning it except the fact itself? How difficult must it have appeared to account for it, on any principle which should exclude the idea of chance!" [5]

Greswell tries to account for these extraordinary coincidences by pointing to Egyptian science as the common fountain of all the analogies of the calendars and of the myths connected with the year; but the assumption is plainly untenable. The Egyptians certainly never taught the Fijians to celebrate the festival of the God of the Dead in November, nor could they have led the Aus-

[5] Fasti Cath., iii. 112.

tralians, the Dayaks of Borneo, and the Mexicans, to regulate their year by the stars in Taurus. If, as he assumes, analogies in the calendars of nations are relics of a primitive year, we must look for it among the most primitive races, and among those who have been least affected by civilization and change.

If this primitive calendar was inherited from primeval antiquity, we may expect to find even among the rudest races some trace at least of their common heritage from the common parent of our race. What do we actually find? In the southern hemisphere, at the equator, and in Mexico, unmistakable proofs of the existence of a primitive sidereal or astral year, regulated by the Pleiades. Among civilized races we find all traditions and myths pointing to a primitive year regulated by Taurus. In Hindostan, November, we have seen, is called the month of the Pleiades, and in the Egyptian calendar was connected with Taurus. In the middle of November and of February, we have found among ancient nations, and even among existing races, either the commencement of a year, or the vestige of an ancient new year's day, still lingering in a festival of the dead; and we have seen that the Pleiades culminate at midnight or sunset at those times which I have mentioned as being so conspicuous in the calendars of nations. The inference from these facts would naturally be that, if any primitive calendar ever existed, we have in the year or seasons of the Pleiades the original type of the primeval calendar.

And this we might infer, even if in the calendars of ancient civilized nations no trace of the primitive type could be found. But I believe that there are some very significant facts, which have already attracted the attention of astronomers in connection with the history of the calendar, and which can only be explained by assuming that all ancient calendars originally partook of the sidereal character of the primitive calendar, and that its progressive tendency is traceable in all ancient calendars.

Though I cannot pretend to deal with these matters as an astronomer, and feel great hesitation in referring to this somewhat difficult subject, there are some simple but significant facts in connection with the history of the calendar, that can be perceived and understood by the most superficial thinker.

Before going into the question, it may be as well to recall the history of our present Gregorian calendar. The correction of Pope Gregory restored the calendar very nearly to what it was in the time of Julius Cæsar, as respects its relation to the tropical year. How then was the calendar affected by the Julian correction in this respect? In the time of Julius Cæsar the year had been so tampered with by the priests, that the months were supposed to have receded more than two months in relation to the

seasons, and to the natural year; accordingly 67 days, exclusive of the intercalary month, were added for the purpose of advancing the months to their proper position. But the exact amount of error in the Roman calendar was probably a mere matter of conjecture, and cannot now be precisely ascertained. Clinton considers that it was much less than has been generally supposed. If so, then the months must have been advanced too far by the addition of 67 days. If this is the case, the effect is most important. For let us assume that the excess in the correction was 28 days, then, if the Pleiades culminated at midnight on the 17th of November in the Roman calendar prior to the Julian correction, their midnight culmination must have subsequently occurred in October; and it would take 2000 years before they would again culminate at midnight, on the same day in November.

Clinton censures Usher for venturing to make precise calculations as to the position of the months in the Roman calendar, prior to, and after the Julian correction; and considers that he attempted "a precision for which we have no authority."[6]

But we have some positive evidence as to the time when the Pleiades set cosmically in the Roman calendar in the second century B.C. I have already shown[7] that in the time of Eudoxus the Pleiades set cosmically on the 14th of November; and Greswell supposes November to have then coincided with Athyr. But the Pleiades must have then set about thirty days earlier than they now do; and consequently November, in relation to our present calendar and to the seasons, must have almost corresponded with our present October; if this was the case, the addition of 67 days was probably nearly 28 days in excess, and November was advanced one month too far in relation to the seasons, and to the natural year.

Let us turn to the Egyptian month of Athyr. It has been very fully demonstrated that the very name of this month, and the rites celebrated in it, show that when it first received its name (more than 3000 years ago), it must have been connected with the constellation of Taurus. That the connection is not merely traditionary, is proved by the Greek epigram on that month, with which this division of my subject is headed, and which is referred to by Greswell.[8] In it Athyr is distinguished as *the month in which the Pleiades are most distinct.* Hesychius says that in the Egyptian "Athyr meant both a *month* and a *bull;*" and Plutarch says that the Phœnicians called a bull *Thor* (Taurus). Greswell explains

[6] Fasti Hellenici, iii. xii. Sir Cornewall Lewis, Hist. Survey of the Astronomy of the Ancients, p. 237.

[7] See ante, p. 70. Also Fasti Cath., iv. 180.

[8] Fasti Cath., iv. 192.

the meaning of Athyr given by Hesychius, by referring to *"a stated connection between the month Athyr and the Bull,"*[9] *i.e.*, Taurus. Athyr is supposed to have fallen three days before the Roman month of November; but this must have had reference to that month before the Julian correction, as November in the Julian calendar nearly coincided with our present month of that name in relation to the tropical year. Thus Greswell says, "the Roman Bruma, according to the calendar, bore date November 24; the beginning of winter, properly so called, was dated *from the cosmical setting of the seven stars;* in the calendar of Cæsar, (?) November 11."[10]

It is therefore plain that the statements,[11] that the Egyptian

[9] Fasti Cath., ii. 503.

[10] The statements of Roman writers, and even of ancient astronomers, as to the calendar, the rising of stars, etc., must be received with great hesitation. Truths applicable to particular latitudes or times were used when or where they were altogether untrue or at least inapplicable. Even Ptolemy is accused of this error by Bailly. See "Astronomia" in Smith's Dict'y of Greek and Roman Antiquities.

[11] I believe that I am correct in my conjectures in p. 23, that the circumstances of the Isia having been fixed to the 17th, 18th and 19th days of the month arose from a superstition which not only existed among the Greeks, the Romans, the Persians, and the Egyptians, as to that day, but also is to be found among the Pacific Islanders (see ante, p. 23) and the natives of Borneo (see ante, note to p. 31), with whom the 17th and 19th nights of the moon are *dies nefasti*, and evidently connected with the monthly commemoration of the dead. A peculiar reverence for the 17th of the month was a feature in the worship of Isis (Fasti Cath., iii. 112, 160), which has already been noticed by writers. Sir Gardner Wilkinson, Bunsen (Egypt's Place in Universal History, iii. 64, 65) and, I believe, all authorities agree that the months received their names when the Isia were instituted, prior to which they had been lunar months, and perhaps simply "moons", like the months of the Australian savages. "Months of their fêtes appear to have been celebrated at the new or the full moon, the former being also chosen by the Israelites for the same purpose; and this, as well as a month being represented in hieroglyphics by a moon, may serve to show that the months of the Egyptians were originally lunar; as in many countries to this day." (Manners and Customs of Ancient Egyptians, i. 227.)

Supposing the primitive year to have been a lunar sidereal year, the monthly festival of the dead, on the 17th, 18th and 19th nights of the "moon", near the time when the Pleiades are most distinct, would have been the great festival of the Pleiades, like that of the Australians; and hence would have been a new year's festival. But when the year was divided into days and months, and ceased to be lunar, the Isia, or rather the festival of the dead, could no longer be a new year's festival, and at the same time fall on the 17th, 18th and 19th days of the month. Hence it would appear that the beginning of the year was so arranged that the 17th, 18th and 19th of Athyr would coincide with, or perhaps *immediately precede*, the midnight culmination of the Pleiades. As the 17th, 18th and 19th of Athyr were clearly a vestige of the primeval new year's festival of the dead, and as the termination of this festival nearly everywhere marked the beginning of the year, it is not improbable that the Pleiades culminated

Athyr began three days earlier than the Roman month of November, must refer to the Roman calendar before the Julian correction. But Plutarch states that the Isia and other funereal celebrations of ancient nations were held "when *the Pleiades were most distinct.*" Hence the Isia and the 17th of Athyr must have corresponded with the midnight culmination of the Pleiades.

It is unnecessary to go more fully into this point at present, as I have shown that the Pleiades culminated at midnight in the middle of the Egyptian Athyr, and of the Roman month of November, at or near the beginning of our era.

As we have seen that the 17th day of Athyr is the *point d'appui* of all calendars, the great landmark of the primitive year, and that the Isia, the most solemn festival of the Egyptians, were always connected with that day; and that, at the beginning of our era, the 17th of Athyr and the Isia fell when the Pleiades were most distinct, let us see what was the nature of the Egyptian calendar. Probably there are few questions more difficult of investigation. Everything connected with the year was veiled in the most profound secrecy; and simple truths were effectually concealed in the most trivial and childish myths. There were probably several modes of regulating the year in use at the same time; there must have been at least a fixed year and a cyclical year; perhaps a sacred year known only to the priests. Hence the 17th of Athyr appears in different forms, as connected with a fixed or

on the 19th or 20th of Athyr. If the Egyptian year commenced on the 29th of August, it would exactly make the 19th of Athyr correspond with the 17th of November. It is probable that the ceremony of "the finding of Osiris," which was celebrated on the 19th of Athyr, really originally symbolized the beginning of "the Pleiades above," and of the primitive year. The same peculiarity is observed in the 17th, 18th and 19th of Anthesterion, which was funereal, being connected with the deluge, and with lamentations, the 20th being marked by rejoicings. This festival of the dead, of three days' duration, beginning with the traditions of the deluge, and with mourning, and ending with rejoicings, almost everywhere *immediately preceded* the beginning of the year. In the new year's festival of Durga, *three* days sacred to the dead are peculiarly marked. Even in the five intercalary days which, at a comparatively late period in Egyptian history, were introduced at the end of the year, we find that the *third* day of the epagomenae. i.e., the third day before the year began, was peculiarly unlucky, and was connected with Typhon and with the memory of the deluge. (Bunsen states that intercalary days were not used.—See Egypt's Place in Universal History, iii. 97; see, however, p. 65 and 79.) In the Yucatan calendar the same thing is observable, as we have seen; the day of the dead (Cemis) did not fall on the first of the five supplementary days, but on the third; i.e., three days before the year commenced. Hence it was plainly a vestige of the primeval new year's festival. If I am correct in my conjecture as to the reference in Job to these days of intercalation, it will indicate that a year, probably of 365 days and of 12 months, was in existence long anterior to what has been hitherto supposed to be the date of its invention.

[83] *To be Continued*

NOTES FROM THE METEOROLOGICAL SERVICE

JULY, 1920

TEMPERATURE

The temperature was about the average in British Columbia, from 2° to 6° above in Alberta and Saskatchewan, from average to 3° above in Manitoba, average or slightly above in Prince Edward Island and Cape Breton, and below average elsewhere over the Dominion, Ontario being very generally from 3° to 6° below, and Quebec, New Brunswick and Nova Scotia from 1° to 3° below.

PRECIPITATION

The precipitation was light in British Columbia conforming to the conditions which usually prevail there in July. In the Western Provinces it was very streaky, some districts receiving a large amount while others in close proximity had very little, as for instance, Calgary recorded 4.90 inches against about 2 inches at Edmonton and Medicine Hat; Moose Jaw 1.80 inches; Regina 5.15 inches; Battleford 4.00 inches; Prince Albert 0.90 inch; Indian Head 5.24 inches; Winnipeg 0.80 inch; however the localities with copious rainfalls were in excess of those with a small quantity. In Ontario, Quebec, and the Maritime Provinces, except in a few isolated spots, the fall everywhere exceeded the average, and in many places to a considerable extent. Some of the large rainfalls reported for the month were ,Mount Forest 6.04 inches; Welland 5.16 inches; Elora 5.43 inches; Kakabeka Falls 5.93 inches; Niagara Falls 7.57 inches; Drummondville 7.31 inches; Kenogami 7.16 inches; Lennoxville 7.66 inches; Roberval 6.70 inches.

TEMPERATURE FOR JULY, 1920

STATIONS	JUNE		STATIONS	JUNE	
	Highest	Lowest		Highest	Lowest
Yukon			*British Columbia—cont.*		
Dawson	92	34	Kamloops	96	48
British Columbia			New Westminster	92	47
Atlin	80	34	Prince Rupert	73	42
Agassiz	94	46	Vancouver	89	48
Barkerville	82	31	Victoria	91	49

TEMPERATURE FOR JULY, 1920—*Continued.*

STATIONS	JUNE		STATIONS	JUNE	
	Highest	Lowest		Highest	Lowest
West Provinces			*Ontario—continued*		
Battleford	94	45	Markdale	—	—
Calgary	92	44	North Grower	87	39
Edmonton	92	43	Oshawa	87	50
Medicine Hat	98	46	Ottawa	88	46
Minnedosa	92	36	Paris	85	43
Moosejaw	100	37	Parry Sound	86	45
Oakbank	88	38	Peterborough	85	43
Portage la Prairie	86	43	Port Arthur	84	39
Prince Albert	95	41	Port Burwell	79	43
Qu'Appelle	98	37	Port Dover	84	46
Regina	102	40	Port Stanley	83	39
Saskatoon	96	43	Queensborough	85	40
Souris	93	40	Ronville	84	39
Swift Current	96	40	Southampton	81	42
Winnipeg	90	40	Sundridge	—	—
			Stonecliffe	90	28
Ontario			Stoney Creek	86	47
Agincourt	84	41	Toronto	87	44
Oak Ridges	83	43	Uxbridge	82	42
Bancroft	87	32	Wallaceburg	87	45
Barrie	84	43	Welland	86	43
Beatrice	84	37	White River	82	28
Bloomfield	81	45			
Brantford	—	—	*Quebec*		
Chapleau	—	—	Brome	83	41
Chatham	90	46	Father Point	81	43
Clinton	86	40	Montreal	90	49
Collingwood	84	40	Quebec	85	46
Cottam	90	49	Sherbrooke	86	43
Georgetown	83	44			
Goderich	—	—	*Maritime Provinces*		
Gravenhurst	84	45	Charlottetown	86	42
Grimsby	84	45	Chatham	84	48
Guelph	81	39	Dalhousie	—	—
Haliburton	90	35	Fredericton	90	38
Huntsville	84	39	Halifax	90	52
Kenora	87	42	Moncton	88	46
Kinmount	—	—	St. John	82	50
Kitchener	84	42	Sussex	84	38
Kingston	79	47	Sydney	86	48
London	87	42	Yarmouth	78	48
Lucknow	83	36			

MAGNETIC DISTURBANCES

JULY, 1920

During the month of July the records obtained at Agincourt and Meanook Observatories indicate a very quiet period in the Earth's Magnetic Field. No pronounced disturbances occurred and the smaller ones were usually of short duration.

Very few meteorological observers report seeing the Aurora during July. Reports were most frequent for the nights of the 11th and 24th.

Sunspots were small and scattered.

EARTHQUAKE RECORDS BY MILNE SEISMOGRAPH, TORONTO

SIR FREDERIC STUPART, F.R.S.C., DIRECTOR

P.T. = Preliminary Tremors. S. = Secondary Waves. L. = Large Waves. A. C. = Air Currents. Time is Greenwich Mean Civil Time; in hours, minutes and decimals of minutes; 0 or 24 h = midnight.

No.	Date 1920		P. T. Comm.	S. Comm.	L. W. Comm.	Max.	End	Max Amp.	Remarks
			h m	h m	h m	h m	h m	mm	
2165	July	2			19 38.7 | 19 43.6 /	19 51.9	Micros	1.3	Thickening. P masked by micros.
2166	"	2			21 42.2	21 52.1	22 07.8	0.2	
2167	"	3			16 52.5 to 16 58.7			0.2	Boom vibrating to 16: 51.5 from local causes Light off till 16:50.5.
2168	"	4			0?52.6 | 0 57.6 /			0.2	
	"	4	Between	15:26.7	and 15:30. it	0h a mar	ked oscill	ation	0.4 amp. Do not think seismic
2169	"	6			3 37.6		3 40.4	0.2	
2170	"	6			4 08.1	4 11.1	4 18.9	0.4	Gradual thickening
2171	"	7			19 02.6	19 02.9	19 36.1	0.9	
2172	"	16			17 32.7	17 33.9	Micros	0.3	Marked micros
2173	"	26			5?17.5 | 5 20.2 /	5 30.5	5 36.0	0.3	Micros

Boom Period 18 seconds. Pillar inclination 1 mm = 0″.45

EARTHQUAKE RECORDS BY MILNE SEISMOGRAPH, VICTORIA, B.C.

F. NAPIER DENISON, SUPERINTENDENT

No.	Date 1920		P. T. Comm.	S. Comm.	L. W. Comm.	Max.	End	Max Amp.	Remarks
			h m s	h m s	h m s	h m s	h m s	mm	
2160	July	2	19 04 04	19 09 58	19 21 46	19 27 40	?	4.0	4120 Km.
2161	"	2	21 58 37			22 35 03	22 51 46	0.4	
2162	"	3	16 51 47		16 55 43	16 58 40	17 10 29	0.2	
2163	"	4	1?02 38			1 07 33	1 15 25	0.2	
2164	"	6	3?24 21			3 26 19		0.1	
2165	"	6				3 44 00	3 57 30	0.1	
2166	"	7	18 48 02		18 49 31	18 50 29	19 13 08	1.75	820 Km.
2167	"	7				20?46 34		0.1	
2168	"	8	2 54 26			3 00 50	3 05 45	0.2	
2169	"	16	17 37 33			17 50 01	18 06 05	0.2	
2170	"	20	1 09 36		1 12 13	1 13 12	1 20 04	0.2	
2171	"	26	5?36 04		5 56 43	6 02 38	6 12 58	0.2	

Period of Boom 18 seconds. Pillar inclination 1 mm = 0″.54

ASTRONOMICAL NOTES

THE MANIFOLD CREED OF THE PRESENT-DAY PHYSICIST

The mind of the physicist may be said to be somewhat in confusion. But there is no reason to hope that it ever will enjoy the logical perfection of a consistent set of theories. He constructs the electromagnetic theory of light and must needs adhere to it on many occasions, yet with full knowledge that it can not be correct. He rejoices in the existence of the universal constant, h, and the appearance of the quantum, $h\nu$, in resonance and ionization potentials, in photoelectric X-ray phenomena, and in the theory of heat radiation, yet he can not be reconciled to the existence of the quantum in the phenomenon of the passage of light through a vacuum. He builds an atomic structure which will not only provide a clear picture, but will also furnish quantitative results in striking agreement with experiment; and yet he must, in his building, reject certain principles which elsewhere he adopts without hesitancy. He rejoices in the achievement of the general theory of relativity, which, unless proved untenable, gives a logical consistency at present—and probably for many, many years, unattainable by other means; yet in his constructive thinking he sometimes uses the ether which the general theory of relativity ignores, and he lives in his old Euclidean world which the present developments from this theory deny.

In short, the physicist can not be consistent. Moreover, he can not progress unless this inconsistency is a stimulus and not an annoyance. He must live as if in several compartments, enjoying in each one the consistency possible therein, and being not distressed but rather interested and invigorated by the failure to unite these compartments into one consistent whole. If he "believes", he must be inconsistent. If he progresses, he must adopt a set of dogmas in the small compartment in his immediate problem. If he follows with full sympathy modern progress in physics, he must have not one, but many dogmas, and these not wholly consistent with one another.

I refer not merely to the multiple-theory method of attack upon a problem, for the dogmas are not even altogether similar in kind, but more especially to the ability to appreciate thoroughly not only "constructive theories", but also "theories of principle" (quoting from Einstein). It is not merely the approach from a different viewpoint in the same universe, but it is the ability to live in more than one universe.

All of this may be obvious, but yet, in point of fact, now and again there appears evidence that even physicists of note are pained by this rôle. They seem to resist by objections which do not aid in the extension of these compartments, or by a rebellion against the obviously advantageous policy of polydogmata.

—G. W. STEWART in "Science".

NOTES AND QUERIES

Communications are Invited, Especially from Amateurs. The Editor will try to Secure Answers to Queries

"THE SUN DRAWING WATER"

Recently the present writer observed on three days the phenomenon of "the sun drawing water". In the first case nothing notable was seen. The streamers radiated from a single centre in various directions, with no similarity of arrangement between those on the right and those on the left of the vertical line through the source.

In the second case a dark cloud prevented one from seeing any streamers to the right of the source. During the observations the sun, about 25° in altitude, came out quite clearly and the streamers could be seen to run up to it. In other words, the source of the streamers was on the line joining the observer to the sun. Indeed that is the peculiar feature of the phenomenon.

The third occasion was especially interesting. It was during the last week in August, and as in the other cases, took place about 3 hours before sunset. The clouds, which appeared over the trees on a hill to the west, were moving rapidly southward and the streamers were also moving with them. This showed certainly that they were produced by the light passing through spaces between the clouds. Indeed the streamers were something like the spokes of a wheel turning about its hub which was in the direction of the sun.

ANOTHER NOVA VISIBLE TO THE NAKED EYE

According to announcenmet in the newspapers, Denning, of Bristol, Eng., discovered on August 21st a nova in Cygnus, of magnitude 2.8 on August 22nd, and thus quite visible to the naked eye. Its position is R.A. 19h 56m; decl. 53° 24′ N., about 11° northerly from Deneb. Soon After its discovery the nova star began to lose in brightness and soon fell to the seventh magnitude or lower. C. A. C.

The Royal Astronomical Society of Canada

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